MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

ECE3086 – MULTIMEDIA TECHNOLOGY AND APPLICATIONS

11 Feb 2023
9:00 A.M – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of five (5) pages only (including this page).
2. There are **FIVE QUESTIONS** in this paper. Answer **ALL QUESTIONS**. Each question carries 20 marks.
3. Write your answers in the Answer Booklet provided.
4. State all assumptions clearly.

QUESTION 1

(a) Describe four advantages of digital audio over the analog versions.

[4 Marks]

(b) The maximum signal frequency for music signals can reach 20 kHz, while the voice signal frequency ranges from 50 Hz to 10 kHz.

i) If the minimal sampling rate (Nyquist rate) is utilised to prevent aliasing, calculate the bit rate obtained by encoding the **mono** voice and **stereo** music signal using pulse code modulation (PCM). Assume that music and voice encoding both use 12 bits per sample.

[8 Marks]

ii) Discuss the effects of reducing the sampling rate and bits per sample by half on the output audio signal's quality.

[4 Marks]

(c) A digital bitmap picture with a dimension of 640x480 pixels is used to depict a colour image. Each pixel uses 24 bits. Determine the image's size in bytes. Suggest a method to represent colour image with less than 24 bits bit depth.

[4 Marks]

Continued ..

QUESTION 2

(a) When video is encoded in YUV format, one approach to lower video bit-rate is colour (chroma) sub-sampling. Explain the rationale for this strategy using the human visual system as an example.

[4 Marks]

(b) Explain the 4:2:2 colour subsampling method on the YUV colour space via illustrations.

[3 Marks]

(c) A video source generates a full-color YUV video with 8 bits per colour component value, a spatial resolution of 640x480, and a frame rate of 60 frames per second. The video employs the 4:2:2 colour subsampling technique and uses 8 bits for each YUV component value. The video will be delivered via a network with a 1.5 Mbps bandwidth. Determine the necessary compression rate that is needed to ensure that the video can be delivered over the network.

[4 Marks]

(d) Create the optimal variable length code for the symbols in Table 2(d) with the use of **Huffman coding method**. You must display the codeword for each symbol. Subsequently, calculate the average bits per symbol for the code you have generated.

[9 Marks]

Table 2(d)

Symbols	Probability of Occurrence
A	0.375
B	0.25
C	0.25
D	0.125

Continued ..

QUESTION 3

(a) JPEG can achieve large compression rate while maintaining acceptable perceptual picture quality. Describe the JPEG compression method using a block diagram. Determine which process or component that contributes to lossy and lossless compression.

[11 Marks]

(b) Figure 3.1 shows the DCT coefficients matrix for an 8x8 image block and Figure 3.2 shows the corresponding 8x8 quantization matrix.

i) Compute the quantized DCT coefficients in the top left 3x3 coefficients matrix and bottom right 3x3. Use the **floor()** function to round the quantized value to the lower and nearest integer value.

[5 Marks]

ii) Explain a justification for the observation in 3(b)(i).

[4 Marks]

510	**65**	**-12**	20	-10	-1	1	-6
-34	**-25**	**11**	13	5	-3	15	-6
-17	**-4**	**7**	-9	3	-3	5	10
8	-10	4	4	-10	10	6	6
12	5	-1	-2	-10	9	-5	-1
5	9	-8	3	4	**-7**	**-14**	**2**
2	-2	3	-1	1	**3**	**-3**	**-4**
-1	1	0	2	3	**-2**	**-4**	**-2**

Figure 3.1: 8x8 DCT Matrix

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

Figure 3.2: 8 x 8 Quantization matrix

Note

a = np.array([-1.7, -1.5, -0.2, 0.2, 1.5, 1.7, 2.0])
np.floor(a) results in
array([-2., -2., -1., 0., 1., 1., 2.])

QUESTION 4

(a) Based on Figure 4.1, examine the DPCM encoder and explain briefly why the encoder apply prediction on the reconstructed signal $\tilde{f}_n$ rather than the original signal f_n .

[4 Marks]

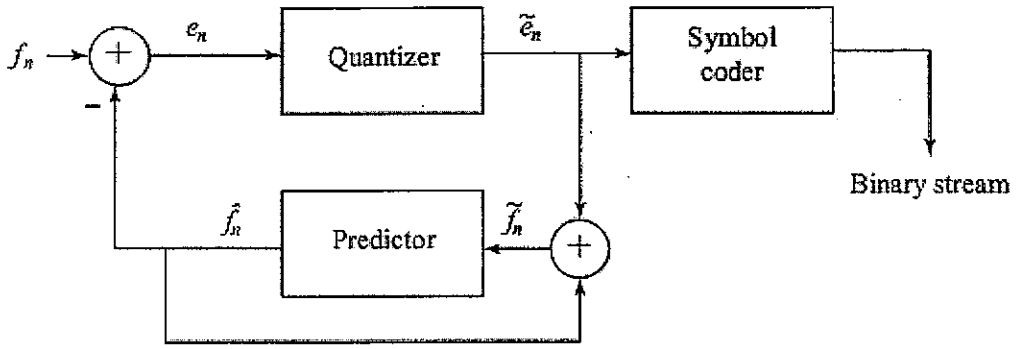

Figure 4.1 : DPCM Encoder

(b) Suggest and discuss two methods to increase the compression rate of the DPCM encoder

[8 Marks]

(c) The MPEG audio compression technology uses a unique method to compress audio samples. The psychoacoustic models are used in the technique to help in the compression of audio samples (frequency and temporal masking). Justify the use of such models and discuss whether MPEG can achieve higher compression than DPCM.

[8 Marks]

QUESTION 5

(a) Design and implement a simple content based image retrieval (CBIR) system that supports query by example. Image is retrieved from the database based on similarity to the query image. As an image descriptor, the system uses the colour histogram in the YUV colour space. Describe the processing steps and show the system block diagram.

[12 Marks]

(b) Design a simple video summarization system where a keyframe is used to represent each video segment. Describe how the K-mean clustering algorithm can be used to implement the video summarization system. All key processing steps must be described.

[8 Marks]

End of Paper